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INVESTIGATION OF SLIP-RING ASSEMBLIES

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Prepared by

IIT Research Institute
Technology Center
Chicago 16, Illinois

for

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Huntsville, Alabama 35812

Attn: PR-RDC

INVESTIGATION OF SLIP-RING ASSEMBLIES

I. INTRODUCTION

This is the sixth quarterly progress report on IITRI Project E6000, "Investigation of Slip-Ring Assemblies." This report summarizes the activities during the period 5 August 1964 to 5 November 1964 and is the second quarterly report on the twelve month continuation authorized by Modification No. 4 of Contract No. NAS8-5251. The objective of the twelve month continuation is to analyze the wear debris that is obtained during run-in of capsules, and to verify the vibration, threshold and repeatability effects that were demonstrated during the original program Subsequent tasks of the extension will be devoted to the study of vacuum operation of slip-ring assemblies.

During the period reported herein, further analysis of wear debris deposits was carried out, and factors influencing the amount of debris produced during run-in were investigated. Studies of precious metal hardening agents for gold plating baths were also continued. Vibration, threshold and repeatibility effects with commercial capsules were verified during the initial quarterly period and the experimental data was summarized in Quarterly Report No. 5.

Table 1 describes run-in tests that were performed during this quarterly period, and Table 2 is a summary of noise measurements during the run-in tests.

TABLE 1

RUN-IN TESTS

CAPSULE	FUNCTION OF TEST
2-33	Collection of Wear Debris From Capsule Having No Previous Run-In; Evaluation of 80° Grooves.
1-37	Effects of Heavy Oil Coating.
2-38	High Current Effects.
Commercial Capsule "B"	Collection of Wear Debris From Commercial Capsule.
1-39	Repeat of Heavy Oil Coating.

TABLE 2

RUN-IN NOISE CHARACTERISTICS

Capsule 2-33

	80° groove		90° groove	
	Peak-to-Peak noise, μv	RMS Noise db	Peak-to-Peak noise, μv	RMS Noise db
initial	45	14.5	35	15.5
after 300 hrs (1)	70	18.0	80	20.0

Capsule 1-37 with P-38 Oil

	80° groove		90° groove	
	Peak-to-Peak noise, μv	RMS Noise db	Peak-to-Peak noise, μv	RMS Noise db
initial	40	11	40	11
after 335 hrs(1)	50	12	50	12

Capsule 2-38, one amp current

	80° groove		90° groove	
	Peak-to-Peak noise, μv	RMS Noise db	Peak-to-Peak noise, μv	RMS Noise db
initial	1000-1800	43	1000-2000	43
after 71 hrs (2)	3000-4000	47	3000-3900	49

Commercial Capsule "B"

	Peak-to-Peak noise, μv	RMS Noise, db
initial	40	12
after 200 hrs (1)	200	24
after 310 hrs (1)	2000-3000	50

Capsule 1-39 with P-38 oil

	80° groove		90° groove	
	Peak-to-Peak noise, μv	RMS Noise db	Peak-to-Peak noise, μv	RMS Noise db
initial	50	11	50	11
after 410 hrs (1)	60	12	60	12

(1) with a current of 25ma for approximately one half of the time

(2) with a current of 1a through both brush-ring circuits in series

(db values taken with reference to 1μv level)

II. ANALYSIS OF WEAR DEBRIS DEPOSITS

A Identification of Wear Debris

During the 300 hour run-in of Capsule 2-33, a very small amount of wear debris was collected. Most of this was found at the top of the grooved portion of the rings, but some was also obtained from the bottom of the grooves. To avoid possible contamination with solvents, the debris was removed in separate portions with the aid of a microprobe using a low power binocular microscope at 27X. Two separate samples of the debris were transferred directly to carbon electrodes for analysis by emission spectrograph. Although the samples were very small, the presence of gold only was detected; all the other trace lines were also indicated in the blank run.

Another portion of the deposit was transferred to a small section of 1/8" copper tubing for attachment to the Bendix time-of-flight mass spectrometer. Since the sample inlet system was not set up for high temperature, the sample was heated to about 500°F using an electric heat gun placed up against the sample tube. No peaks other than normal background were recorded; however, a short burst (about 1 second duration) of hydrocarbons was observed. The highest peak appeared to be in the 120-140 m/e range.

A third sample of debris was left intact on one of the brushes and mounted for analysis by the electron probe.

Even though the deposit displayed a black appearance under normal illumination, the typical gold color was observed when light was reflected from the wear particles at the proper angle, and viewed under the microscope.

The trace constituents of calcium, aluminum, magnesium and iron reported previously were apparently due to contamination of the electrode system and/or the solvent extraction step and not due to the bearing lubrication or other sources within the capsule.

B. Acceleration of Wear Debris

To investigate whether the bearing lubrication was a causative factor in the rapid accumulation of deposits, Capsule 1-37 was assembled with a thin coating of P-38 oil on the ring and brush contacting surfaces. After 335 hours of run-in at 200 rpm, hardly any increase in noise level was detected with either the 80° or 90° grooves.

Inspection of Capsule 1-37 under the microscope revealed that too little wear debris had accumulated to collect, and therefore, no analysis was attempted. The results of this test suggest the desirability of some added lubrication for reducing slip ring frictional wear. This is analogous to the experience with TV tuners, where it is necessary to use a lubricant on the precious metal alloy of the contact springs to reduce wear of the alloy and give long life.

To confirm the excellent noise and wear characteristics obtained with the lubricated capsule, a second capsule coated with P-38 oil was assembled and tested. After 410 hours of run-in at 200 rpm, Capsule 1-39 showed almost no increase in noise level, thus verifying that lubrication of the contacting surfaces is effective in reducing noise. Although very little debris is expected, Capsule 1-39 will be disassembled and inspected for wear effects.

C. Commercial Capsule Run-In

The run-in test of Commercial Capsule "B" was performed at 200 rpm with a brush current of 25 ma. The first evidence of noise increase appeared after about 200 hours of operation with peak-to-peak noise spikes of about 200 μv. The noise continued to increase rapidly to levels of 2000-3000 μv at about 300 hours, and the test was terminated. During the test, the RMS noise level increased from the original 12 db above the 1μv level to a final value of 50 db.

The commercial 80 circuit capsule assembly was opened to collect the wear debris. It was observed that the wear products were not typical of previous experience with the experimental capsules. A large quantity of about 0.060 grams of wear material was collected and studied under the microscope. The major wear debris in this case is composed of small gold chunks, flakes and slivers of various sizes, almost all comparatively large. A few pieces of epoxy resin were observed and also a few pieces of the welding or soldering alloy used to hold the brushes on the brush block. One of the brushes had broken off at the welded junction and a number of the brushes were no longer in contact with the rings. In a few cases, slivers of gold were adhering to one ring which were long enough to touch and possibly short to an adjacent ring.

These results suggest that either the contact surfaces in a commercial capsule are significantly different from those in the experimental capsules or that the mechanical loading or thermal effects are more severe. These factors will be investigated during the coming period.

III. BASIC NOISE CHARACTERISTICS

A. High Current Tests

A run-in test of Capsule 2-38 was also completed to obtain information on the high current performance of the slip-ring system. Noise was measured for a brush current of 1 ampere flowing through two brush-ring circuits in series. The initial noise level ranged from 1000 to 1800 μv. and after 70 hours of run-in at 200 rpm, the noise level was 3000 to 4000 μv. Disassembly of Capsule 2-38 revealed very little debris and almost no permanent damage to the brush or ring surfaces. Apparently, the present brush-ring system is capable of safe operation at relatively high currents with almost a linear increase in the noise per unit of brush current.

B 80° "V" Grooves

All experimental capsules used for the run-in tests performed during this quarterly period utilized a ring cylinder having two 80° and two 90° grooves. During the run-in tests, current was supplied to each pair of grooves for approximately one-half of the total test time with frequent changes from one pair to the other. Although test results with Capsule 2-33 indicated some advantage for the 80° grooves, subsequent tests have not demonstrated any significant differences between the two systems. In all recent tests of experimental capsules, both the 80° and 90° systems have demonstrated excellent noise characteristics, but differences may have been masked by the beneficial effects of surface lubrication.

IV. PRECIOUS METAL HARDENING AGENTS

Work during this reporting period covered the microhardness evaluation of electrodeposits from various rhodium-modified gold plating baths and the procurement of additional stock gold plating solution (Orotemp 24) as well as two other candidate precious metal hardening agents, palladium chloride ($PdCl_2$.dry and purified), and platinic chloride (in the form of Fisher Reagent grade Chloroplatinic Acid). Rhodium and palladium both belong to the low atomic weight family of precious metals (Ru, Rh and Pd) whereas platinium belongs to the high group (Os, Ir and Pt).

The microhardness determinations on electrodeposits from the rhodium-treated Orotemp 24K gold bath are summarized in Table 3. The specimens were plated at a current density of 5 amperes per square foot from an Orotemp 24 bath with progressively increasing rhodium/gold ion ratios as listed in the table The specimens were mounted in Bakelite holders and polished metallographically. Microhardness determinations were conducted on the polished gold surfaces using an Ernst Leitz Durimet machine. This device utilizes a square base pyramid diamond indentor which is provided with a variable loading feature. Hardness values were taken at two indentor load levels. 15 and 25 grams. Referring to the table, it is immediately apparent that an unexpected trend in hardness was found. Whereas the rhodium level in the bath increased, the hardness exhibited a significant decrease. It can be seen that there is some variation in hardness from spot to spot in the deposits also.

Work is underway to prepare electrodeposits from a palladium-modified gold bath. Some difficulty was encountered in getting the palladium chloride to go into solution in making up stock solution, but this problem was overcome by acidifying the water slightly. It remains to be seen if the palladium ion is stable in the neutral pH range of the Orotemp 24 bath.

TABLE 3

MICROHARDNESS DATA ON Au-Rh-ELECTRODEPOSITS

Ring No.	Rh/Au Ion Ratio in bath	Range of Hardness in Deposit VHN_{25g}*	VHN_{15g}
44	0.0000	102-116	97-101
45	0.0001	100-118	89-105
46	0.001	91-101	83-93
47	0.01	59-91	76-87

* VHN_{25g} = Vickers Hardness Number, 25 gram indentor load.

V. SUMMARY

The spectrographic analyses of wear debris conducted thus far have indicated that the primary constituent is gold from the ring surface. Some evidence of a minor hydrocarbon component has been obtained, but further analysis is required for conclusive identification.

Run-in tests of experimental capsules have demonstrated that surface lubrication is particularly effective in maintaining low noise levels and in minimizing wear of the ring and brush surfaces.

A run-in test of a commercial capsule has indicated that there is a significant difference in the nature of the wear deposit that is accumulated during run-in. Further investigation is required to establish the cause of this difference.

Experiments with various rhodium-modified gold plating baths have indicated that the hardness of the plate decreases as the concentration of rhodium ions increases.

VI. FUTURE ACTIVITIES

During the next quarterly period of this program, the following activities will be performed:

A. Additional studies of surface lubrication will be conducted to determine the existance of the best lubricant, if any.

B. Metallurgical studies will be performed to determine the causes of the significant differences in run-in characteristics of the commercial and the experimental capsules.

C. The study of precious metal hardening agents will be continued.

D. Preparation for vacuum testing of experimental capsules will be initiated.

VII. PERSONNEL

IITRI staff members who have participated in the activities described in this report are O.M. Kuritza, W.H. Graft, and R.E. Putscher.

Respectfully submitted,
IIT RESEARCH INSTITUTE

J.L. Radnik
J.L. Radnik
Assistant Manager
Reliability and Components

Approved:

M.E. Goldberg
M.E. Goldberg
Manager
Reliability and Components